

Agricultural biomass as provisioning ecosystem service: quantification of energy flows

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Contact information

Maria Luisa Paracchini

Address: Joint Research Centre, Via Enrico Fermi 2749, TP 266, 21027 Ispra (VA), Italy

E-mail: luisa.paracchini@jrc.ec.europa.eu Tel.: +39 0332 78 9897

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Table of contents

Abstract	1
1. Introduction	3
2. Energy Return on Investment (EROI) and Net Energy Balance (NEB) as possible metrics to describe provisioning services delivered by agro-ecosystems	5
3. Analytical framework for the quantitative assessment of EROI and NEB	9
3.1 Introduction	9
3.2 The CAPRI energy balance model	10
3.3 Approach to calculate a soil energy balance	12
3.3.1 Calculation of EROI and NEB at regional and HSMU level	15
3.3.2 Calculation of the reference scenarios	17
3.3.3 Calculation of the economic value	18
4. Results	19
4.1 EROI and NEB – Actual farming system	19
4.2 Relation between input and output	28
4.3 Relation between NEB and economic value	29
4.4 Comparing EROI and NEB of actual farming situation against varying levels of human interference in ecosystems	34
4.4.1 Comparison of EROI and NEB for actual farming situation and reference scenarios (total biomass)	34
4.4.2 Comparison of EROI and NEB for actual farming situation and reference scenarios - food biomass	47
4. Discussion	53
5 Conclusions and recommendations	59
References	61
Annex 1 - Grouping of crop groups for presentation and analysis of final energy balance calculations	65
Annex 2 - Calculating energy input for spreading manure	67
Annex 3 - Calculating energy input through labour	69
Annex 4 - Energy content of output of food, feed and other biomass	71
Annex 5 - Allocation of input and output variables from region to HSMU	75
Annex 6 - Preparation of the three reference layers with the MARS-CGMS system	77
Annex 7 - Analysis of most suitable crop aggregates for presentation of results	83
Annex 8 - Land use, input and output information per country and environmental zone	85
Annex 9 - Variation in input levels per crop	103
List of abbreviations and definitions	109
List of figures	110
List of tables	112

Abstract

Agro-ecosystems supply provisioning, regulating and cultural services to human society. This study focuses on the agro-ecosystem provisioning services regarding the production of agricultural biomass. These services strongly respond to the socio-economic demands of human beings, and are characterised by an injection of energy in the ecosystems production cycle which is often exceeding the ecological capacity of the ecosystem, i.e. the overall ability of the ecosystem to produce goods and services linked to its bio-physical structure and processes that take place during the agricultural production. Agricultural production is identified as ecosystem service in widely recognised ecosystem service frameworks, but currently there is no clear agreement within the scientific and policy communities on how the ecological-socio-economic flow linked to this provisioning service should be assessed, beyond a mere accounting of yields. This study attempts to provide a new insight to this issue by proposing an approach based on the energy budget, which takes into consideration the energy needed by the ecosystem to supply the service. The approach is based on the concepts of Energy Return on Investment (EROI) and Net Energy Balance (NEB), and considers different bio-physical structures and processes of agro-ecosystems. The work is structured in three parts: the first aims at estimating inputs (machinery, seeds, fertilizers, irrigation, labour) in energy terms; the second at estimating biomass output in energy terms; the third to compare actual agricultural production with three reference scenarios encompassing a range of human input (no input – low input – high input scenarios). Results show that in general terms cereal and grassland systems have the largest energy gains (both in terms of EROI and NEB). Such systems are characterised by a lower economic value of their output compared to other producing systems such as fruits, which have lower energy gains but a higher embodied energy, which is recognized in the market as valuable. Comparison of actual production systems with the high input scenario confirms that current production in Europe is already highly intensive, and that increasing the energy input would not improve the efficiency of the conversion of such additional energy into biomass. Overall, the proposed approach seems a useful tool to identify which are the factors in the agricultural production process that could be modified to improve the energy efficiency in agricultural systems and the sustainability of their production. This study can be considered as a first step in the assessment of the total energy balance of the agro-ecosystem. In fact it deals with the quantification of energy regarding human inputs and the corresponding output and further analysis should address crucial issues such as the quality of the energy and the embodied energy in the plant production, which will help to better understand the complexity of the agro-ecosystems.